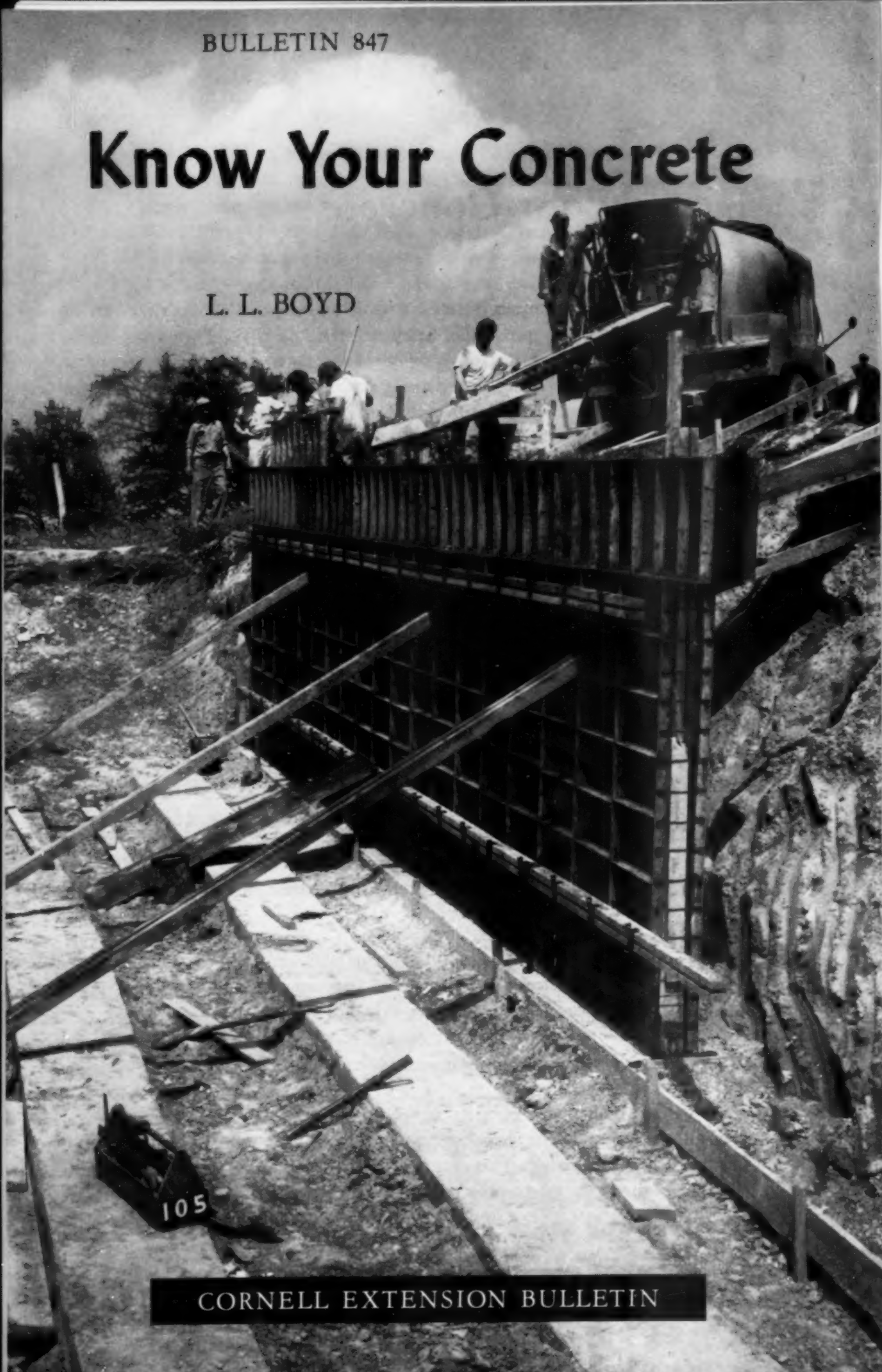
BULLETIN 847

Know Your Concrete

L. L. BOYD



CORNELL EXTENSION BULLETIN

Know Your Concrete

L. L. Boyd

Do you "know your concrete" so you will have the best that can be made for any particular purpose when it is used on your farm? If not, this publication will be of interest to you.

Concrete has been used extensively for many years, particularly for industrial buildings, large dams, and highways. It has also been used commonly on farms for foundations, footings, piers, floors, silos, tanks, and bridges. Concrete has become a popular construction material because it is durable, sanitary, fire-resistant, easy to place in a variety of shapes, and can easily be made attractive in appearance. In addition, it requires little time and effort for maintenance.

The satisfaction which a particular concrete installation gives depends greatly upon the individual or individuals who prepare it. Concrete must be properly proportioned, mixed, placed, and cured if it is to be of the highest quality. It must be made of good-quality materials as well, because low-quality materials never produce a high-quality product.

Materials

Concrete is composed of cement, water, and aggregates which after being properly mixed together harden into a rock-like mass. This hardening is a chemical reaction, known as "hydration," between the cement and water with the release of a considerable amount of heat. It should be understood that the hardening of concrete is not "drying" as it is so often called. This fact is of great importance in the curing process.

Cement

The active ingredient in concrete is portland cement, which is a finely ground material composed primarily of compounds of lime, with silica, alumina, and iron oxide. Of the five types of portland cement, Type I is most commonly used for general concrete construction. The other four types have special qualities, such as high early strength, sulfate resistance, and low heat of hydration.

The manufacture of cement is well standardized and the only precaution necessary when purchasing cement is to be sure that it is free from lumps. The lumps may or may not be harmful, depending upon what has caused them. Lumps resulting from the weight of other cement being piled on it are not harmful. They can be pulverized by striking

them lightly with a shovel. Those that result from the absorption of moisture are harmful because they indicate that part of the setting process has already taken place. This means that the quality of the cement is lower than that which is free from lumps. These lumps cannot be pulverized nearly so easily as those resulting from compaction. For this reason, care should be taken to store cement only in dry places. It should never be placed closer than 6 inches to concrete floors or walls. In addition, it is well to provide for free air circulation around and under it.

Cement is normally packaged in bags containing 1 cubic foot and weighing 94 pounds. It is, however, sometimes shipped in the bulk.

Aggregates

The aggregate in concrete makes up from two-thirds to three-fourths of the total volume. It is therefore easy to understand the importance of selecting materials that are sound, hard, and durable. It is also important that they be clean so that the particles will be well-bound together.

Aggregate is generally considered to be composed of fine aggregate and coarse aggregate. Fine aggregate is that material which will pass through a screen with $\frac{1}{4}$-inch openings. Not more than 30 per cent of a fine aggregate should pass through a screen with $^1/_{50}$-inch openings. Coarse aggregate ranges from that which will not pass through the $\frac{1}{4}$-inch openings up to that $1\frac{1}{2}$ inches or more in diameter. Building codes usually limit coarse aggregate to a diameter not greater than one-fifth of the wall or slab thickness in which it is being used. In addition, its diameter should not exceed three-fourths of the smallest opening through which it must pass during placing. Occasionally, large stones are permitted in large reinforced slabs where there should be at least 6 inches of cement and fine aggregate mortar between each stone. This is known as "cyclopean concrete."

Fine aggregate

Sand is the most commonly used fine aggregate, although crushed stone is frequently used. Crushed stone, if used, should be free of dust. Sand often contains clay or silt and organic matter. Excessive amounts do not permit a good bond between the cement-water paste and the aggregate and retard the hardening process as well. For this reason, tests have been devised to determine whether objectionable amounts are present.

The silt test is used to determine the amount of silt or clay in the sand or other fine aggregate. To make the test, about 2 inches of sand is placed in a quart fruit jar. The jar is filled with water to within $2\frac{1}{2}$ inches of the top, and shaken thoroughly for one minute, leaving the sand as level as possible. Then the jar is left undisturbed for at least one hour. If the silt that settles is more than $\frac{1}{8}$ inch in thickness, the sand

FIGURE 1. SAND THAT CONTAINS TOO MUCH SILT FOR GOOD CONCRETE
Sand, such as this, should be washed and retested before it is used.

should be washed before it is used in concrete. The sand shown in figure 1 contains too much silt and must be washed before it is used. Often it is more economical to buy the necessary sand rather than attempt to wash it. This is especially true if it contains excessive amounts of both silt and organic matter.

The amount of organic matter present may be determined by the colorimetric test. A 3 per cent solution of sodium hydroxide or caustic soda is needed and can be made by dissolving 1 ounce of sodium hydroxide (available at any drug store) in 1 quart of water. Four heaping teaspoonfuls of household lye are enough for 1 quart of water. Serious burns may result from handling sodium hydroxide with wet hands. Sodium hydroxide also damages clothing, leather, and many other materials. After the sodium hydroxide solution has been prepared, an ordinary 12-ounce prescription bottle is filled with 4½ ounces of sand, and then the sodium hydroxide solution added until the 7-ounce mark is reached. The mixture should be shaken thoroughly and allowed to stand for 24 hours. At the end of that time the color of the liquid will be the index of the amount of the organic matter present in the sample. A clear, colorless liquid indicates that no organic matter is present, while a straw-colored liquid indicates some organic matter but not objectionable amounts. Any dark color indicates harmful amounts, and the sand should be washed and retested before being used. About what can be expected for the three stated conditions is illustrated in figure 2.

Coarse aggregate

Coarse aggregates used in concrete are gravel, crushed stone, cinders, and blast-furnace slag. The above tests are not often made on coarse aggregate because one can usually detect the presence of silt, clay, and organic matter by close observation.

Crushed stone and gravel should be hard and durable and somewhat round in shape. Trap, granite, and

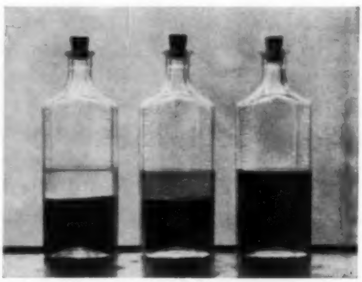


FIGURE 2. RESULTS OF THE COLORIMETRIC TEST FOR THE PRESENCE OF ORGANIC MATTER
The sand in the right bottle should be washed before it is used in concrete.

limestone are most suitable. Limestone, however, should not be used if the concrete will be exposed to acids of any kind.

Cinders used for coarse aggregate should be hard and free from sulfur, unburned coal, and fine ash. Hard-coal cinders are preferred because they contain smaller amounts of the undesirable impurities mentioned. The strongest cinder concrete results from the use of the heaviest cinders containing a minimum of fine material. Cinders should not be used if water tightness or considerable strength is desired.

Blast-furnace slag may be used if available, but like cinder concrete is not suitable for water-tight concrete. It should be tough and dense, the sulfur content low, and have been properly air cooled.

Expanded mica or vermiculite is sometimes used as aggregate to give concrete insulating properties. This kind of concrete bears little load. The manufacturers of vermiculite generally provide the necessary information for its use.

Water

The water that is used to mix concrete should be clean and should contain no acids, alkalis, or oil. Water that is suitable for drinking purposes is considered to be satisfactory for mixing concrete.

Proportioning

The most important point in the mixing of concrete is the water-cement ratio. The water-cement ratio means the amount of water added to a given amount of cement, and is usually referred to as gallons per sack. It has been proved that the strength of concrete is directly related to the amount of water used in the cement-water paste so long as the mix remains plastic and workable. It is *impossible to over-emphasize the importance of the water-cement ratio.* The great decrease in the strength of concrete as the water-cement ratio is increased is illustrated in figure 3.

The water-cement ratio means little unless the moisture contained in the aggregate is taken into consideration. The majority of the moisture in the aggregate is contained in the sand. Sand is generally classified as dry, damp, wet, or very

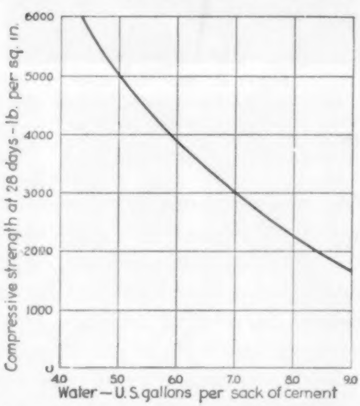


FIGURE 3. EFFECT OF QUANTITY OF MIXING WATER ON STRENGTH OF CONCRETE

Quality of concrete is related to the quantity of mixing water used per sack of cement.

FIGURE 4. DAMP SAND
Damp sand falls apart after being squeezed into a ball. It leaves very little moisture on the hand, and contains approximately 1 quart of water.

FIGURE 5. WET SAND
Wet sand remains in a ball after being squeezed. It leaves a little moisture on the hand, and contains approximately 2 quarts of water.

FIGURE 6. VERY WET SAND
Very wet sand remains in a ball after being squeezed, and is dripping wet. It leaves the hand very wet, and contains from 3 to 5 quarts of water.

wet. Dry sand is seldom found for use in concrete.

Dry sand is that which is as dry as if it had been spread out in a thin layer and dried in the sun or warm air. It is characterized by the fact that it flows freely.

Damp sand is that which feels slightly damp to the touch but leaves very little moisture on the hand. It also falls apart after it has been squeezed into a ball in the hand. A cubic foot of damp sand contains approximately 1 quart of water (figure 4). Wet sand is the kind generally available for use. It feels wet and leaves a little moisture on the hand. After being squeezed into a ball, it remains in that shape (figure 5). Wet sand contains approximately 2 quarts of water per cubic foot. Very wet sand is dripping wet and leaves the hand very wet (figure 6). It remains in a ball and in addition will sparkle. A cubic foot of very wet sand contains about 3 quarts of water and, if there is a large amount of fine material in it, the sand may contain as much as 5 quarts per cubic foot.

The ratio of fine aggregate to coarse aggregate is an important part in concrete economy and it also affects quality. The cement is the most expensive ingredient in concrete and the amount required for a unit

FIGURE 7. WELL-GRADED COARSE AGGREGATE (GRAVEL)
Width of strips show proportions of each size.

volume of concrete is dependent upon the size and gradation of the aggregate used. The least cement-water paste is required when the aggregate presents a minimum of surface area and void-space volume because, for the highest quality of concrete, each particle must be completely coated and all voids filled with the paste. A well-graded coarse aggregate is shown in figure 7 and a well-graded fine aggregate (sand) in figure 8. A sand that does not have enough large particles is shown in figure 9. A volume of small particles has almost twice as much surface area as an equal vol-

FIGURE 8. WELL-GRADED FINE AGGREGATE (SAND)
Width of strips shows proportion of each size.

FIGURE 9. POORLY GRADED FINE AGGREGATE (SAND)

Excessive amounts of cement-water paste are required to coat large surface area. Width of strips show proportions of each size.

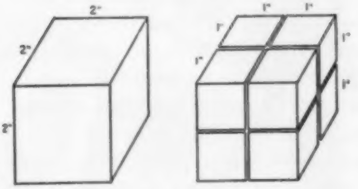


FIGURE 10. A CUBE WHOSE SURFACE AREA IS DOUBLED BY CUTTING INTO FOUR SMALLER CUBES

Volume is unchanged. The same relationship holds true for spherical particles.

ume of particles twice their diameter. This is shown by cutting the cube in figure 10. The same relationship holds true for spherical shaped particles. A volume of the larger particles, however, contains more void space. It is easy to see that the ideal condition exists when there are enough small particles of varying sizes to fill the void spaces between the larger particles. With well-graded aggregate, this condition usually exists when the proportion of total aggregate is about 40 per cent fine aggregate (generally sand) and 60 per cent coarse aggregate.

Bank-run gravel, which is often used in concrete, seldom contains the correct proportions of fine and coarse aggregate. For this reason, in addition to the test for silt and organic matter, the percentages of coarse and fine aggregates should be checked. This can be done by screening random samples through a ¼-inch screen. If the correct proportions do not exist, it would be wise to screen enough to add, or perhaps purchase, a quantity of that which is needed to make the proportions correct. It is relatively easy to determine by the appearance of the concrete whether or not proper aggregate proportions exist. Concrete with the proper fine aggregate-coarse aggregate ratio is shown in figure 11; that with too much fine aggregate in figure 12; that with too much coarse aggregate in figure 13.

FIGURE 11. A CONCRETE MIXTURE WITH THE CORRECT AMOUNT OF CEMENT-SAND MORTAR

With light troweling, all spaces between coarse aggregate particles are filled with mortar. Note the appearance on the edges of the pile. This is a good workable mixture and will give a maximum yield of concrete with a given amount of cement.

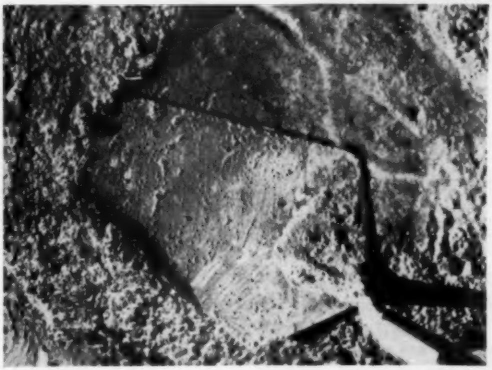


FIGURE 12. A CONCRETE MIXTURE WITH AN EXCESS OF CEMENT-SAND MORTAR

While such a mixture is plastic and workable and will produce smooth surfaces, the yield of concrete will be low and consequently uneconomical. Such concrete is also likely to be porous.

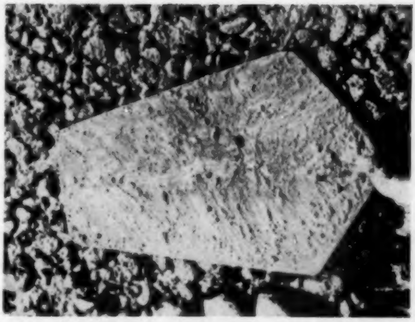


FIGURE 13. A CONCRETE MIXTURE WITH NOT ENOUGH CEMENT-SAND MORTAR TO FILL ALL THE SPACES BETWEEN THE COARSE AGGREGATE PARTICLES

Such a mixture will be difficult to handle and place and will result in rough, honeycombed surfaces and porous concrete.

The workability of concrete is affected by the proportioning and can be measured by the slump test. A suggested water-cement ratio and the fine aggregate-coarse aggregate proportions for several uses of concrete are given in table 1, based upon a well-graded aggregate and a 5-inch slump. Varying degrees of workability are required for different concrete uses. Some recommended slumps are shown in table 2. A slump cone (figure 14) should be filled immediately

Table 1. Recommended Proportions of Water to Cement and Suggested Trial Mixes

Kinds of work	Add U. S. gallons of water to each sack batch if sand is			Suggested mixture for trial batch			Materials per cubic yard of concrete*		
	Very wet	Wet	Damp	Cement sacks	Aggregates: Fine Cu. Ft.	Aggregates: Coarse Cu. Ft.	Cement sacks	Aggregates: Fine Cu. Ft.	Aggregates: Coarse Cu. Ft.
5-gallon paste for concrete subjected to severe wear, weather, or weak acid and alkali solutions									
Colored or plain topping for heavy wearing surfaces as in industrial plants and all other two-course work such as pavements, walks, tennis courts, residence floors, etc.	4¼	Average Sand 4½	4¾	1	1	1½	10	12	15
				Maximum size aggregate ⅜"					
One-course industrial, creamery and dairy plant floors and all other concrete in contact with weak acid or alkali solutions.	3¾	4	4½	1	1¾	2	8	14	16
				Maximum size aggregate ¾"					
6-gallon paste for concrete to be watertight or subjected to moderate wear and weather									
Watertight floors such as industrial plant, basement, dairy barn, etc. Watertight foundations. Concrete subjected to moderate wear or frost action such as driveways, walks, tennis courts, etc. All watertight concrete for swimming and wading pools, septic tanks, storage tanks, etc. All base course work such as floors, walks, drives, etc. All reinforced concrete structural beams, columns, slabs, residence floors, etc.	4¼	Average Sand 5	5½	1	2¼	3	6¼	14	19
				Maximum size aggregate 1½"					
7-gallon paste for concrete not subjected to wear, weather, or water									
Foundation walls, footings, mass concrete, etc., not subjected to weather, water pressure or other exposure.	4¾	Average Sand 5½	6¼	1	2¾	4	5	14	20
				Maximum size aggregate 1½"					

*Quantities are estimated on wet aggregates using suggested trial mixes and medium consistencies—quantities will vary according to the grading of aggregate and the workability desired.

It may be necessary to use a richer paste than is shown in the table because the concrete may be subjected to more severe conditions than are usual for a structure of that type. For example, a swimming pool ordinarily is made with a 6-gallon paste. However, the pool may be built in a place where soil water is strongly alkaline in which case a 5-gallon paste is required.

after the concrete is mixed. This is done in three steps and each portion is vibrated with twenty-five strokes of a rod, taking care not to penetrate the previous layer. Immediately after the last layer has been placed in the slump cone, the cone is removed and the slump is measured as shown in figure 14. If the desired slump is not obtained, the ratio of fine aggregate to coarse aggregate should be altered. Slump can be decreased by adding more fine aggregate and reducing the coarse aggregate. It can be

Table 2. Recommended Slumps for Concrete

Type of structure	Slump in inches	
	Minimum	Maximum
Massive sections; pavements and floors laid on ground	1	4
Heavy slabs, beams, or walls; tank walls; posts	3	6
Thin walls and columns; ordinary slabs or beams; vases and garden furniture	4	8

FIGURE 14. SLUMP IS MEASURED FROM A ROD LAID ACROSS THE TOP OF THE SLUMP CONE

increased by increasing the coarse aggregate and decreasing the fine aggregate. Concrete with the correct slump is not so likely to segregate while being transported and placed.

Tools and Equipment

THE equipment needed for mixing, handling, and placing concrete depends upon many things.

The equipment needed for hand mixing includes one water-tight mixing platform about 8 by 10 feet (any smooth level surface or mortar box may be substituted); square-pointed shovel or mixing hoe; water supply; water bucket; sand screen with ¼-inch openings if bank-run gravel is to be used; and a measuring box. The measuring box should have a capacity of 1 or 2 cubic feet and be made without a bottom. A box 12 by 12 by 12 inches holds 1 cubic foot of material, and a box 18 by 18 by 10⅝ inches holds 2 cubic feet.

If the mixing is not done near the place where the concrete is being used, a rubber-tired front-dump metal wheelbarrow is useful.

If mixing is done by machine, the equipment needed is: one mixer of adequate size; a source of power for the mixer; shovels; water supply; water buckets; and possibly a measuring box. Again, a wheelbarrow is needed if the mixer is placed any great distance from the place where the concrete is being used. The size of the mixer depends upon the amount of concrete being placed, the manpower available, and how fast one wishes to place the concrete. After the concrete has been mixed and transported to the forms, some other equipment is needed. Included are: a tamper or vibrator to remove air pockets, a spade to force the stones

away from the face of the forms, and various trowels, wood floats, levels, edgers, groovers, and the like to accomplish the desired finish.

Ready-mixed or transit-mixed concrete is used on large jobs. Trucks that haul as much as 3 cubic yards of concrete deliver it at the site where it is to be placed. If ready-mixed concrete is used, only the finishing tools and equipment will be needed. Ready-mixed concrete reduces the labor of mixing and carrying, and results in more uniform lots. If labor is considered, as it should be, ready-mixed concrete probably is as cheap as mixing at the farm unless it must be hauled a considerable distance.

Mixing

Good concrete can be mixed by hand, but machine mixing is preferred because thorough mixing is easier to obtain and more nearly uniform batches result. The important point, however, is that the particles of the aggregate be completely covered with a thoroughly mixed cement-water paste.

Machine mixing

Practically all of the standard-batch mixers on the market are satisfactory. When using this type of machine, it is recommended that the mixing continue for at least 1 minute, and preferably 2, after all materials, including water, have been placed in the mixer. Tests show that the strength of concrete increases appreciably as the mixing time is increased from 15 seconds to about 2 minutes as shown in figure 15. In addition, more uniform concrete is obtained by mixing 2 minutes or longer.

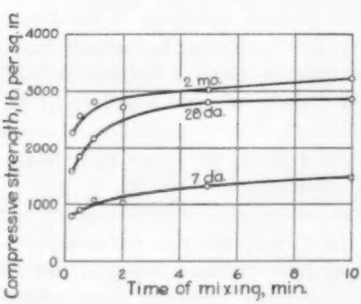


FIGURE 15. EFFECT OF TIME OF MIXING UPON CONCRETE STRENGTH, FOR STATIONARY MIXERS

Reproduced with permission from *Effect of Time of Mixing on the Strength of Concrete* by Duff A. Abrams, in the Proceedings of the ACI (Volume 14, page 27).

Changes in mixer speed have little effect on concrete strength. Overloading prevents thorough mixing and results in a decrease in strength.

Whenever the mixer is not used for any length of time, it should be thoroughly cleaned and washed. This can best be done by letting it run with water and coarse aggregate, which tends to scour. Caked concrete probably will have to be broken loose with a light hammer.

Hand mixing

When concrete is to be mixed by hand, it is well to have a definite

method of mixing and to adhere to it. Several methods are employed; each gives equally good results. The first step generally is to measure the sand and spread it evenly on the mixing platform or in the mortar box, add cement, and mix the two until the color is uniform. After this, the gravel is mixed with the sand and cement and after that has been mixed thoroughly, the water is then added. All should be thoroughly mixed until every particle is coated with the cement-water paste. Other persons prefer to add the water to the cement and sand mixture and later add the coarse aggregate, claiming that this method requires less labor.

Placing

CONCRETE should be placed in forms just as soon as possible after mixing. Forty-five minutes is the absolute maximum time limit because the initial set will have taken place by that time. Any movement of concrete after the initial set reduces the strength.

Care should be taken to prevent segregation of coarse and fine particles when handling and placing concrete. Long hauls over rough runways or roads; too much tamping, spading or vibrating; dropping the concrete from a considerable height; and dumping at one point and allowing it to run and spread out are the most common causes of segregation. The result is stratified concrete, with an abundance of very fine material at the surface which chips, chalks, and wears unevenly. Concrete should be placed in forms in layers up to 12 inches in thickness. These layers should be vibrated and spaded just enough to make it settle thoroughly and to produce a dense mass. The spade forces the large stones away from the forms so that when the forms are removed the concrete will be smooth with no aggregates exposed. Vibration also helps to prevent air pockets from forming along the sides of the forms.

Forms

FORMS, of course, must be made to the correct size and shape. In addition, they must be strong and supported well enough to retain their shape after the concrete has been placed. The forms should be tight to prevent the escape of the cement-water paste.

Ease of erecting and filling and of removing forms is likewise important. Bolts, screws, and double-head nails are often used to facilitate removal. If forms are to be used only once or twice, the cost must be kept low.

Several materials have been used for forms, but wood is the most common. The lumber should be free from knots and decay. When very smooth surfaces are desired, the lumber should be matched; quite smooth walls can, however, be obtained with lumber dressed on four sides. Also, plywood has been used successfully when it has been well supported to prevent bulging.

The forms should be oiled with a light lubricating oil. The oil brushes more easily if diluted with an equal amount of kerosene. This prevents the concrete from sticking to the lumber, and also keeps the lumber from absorbing some of the water and upsetting the water-cement ratio. Lubricating oil should not be used on forms where the concrete is to be stuccoed, plastered, or painted because some of the oil will remain on the surface and the stucco, plaster, or paint will not adhere well. A paraffin oil should be used if one expects to stucco, plaster, or paint the concrete. Earth is often used as a form for foundations and footings. If it is used, it should be firm so there will be no danger from caving. Plank runways should be placed along the edge while the concrete is being placed, to further insure against caving. Dirt in concrete reduces the strength and increases porosity. It is well to line the excavation with roll roofing or tar-paper to reduce the absorption of water which will reduce the water-cement ratio.

The forms may be taken off after one to two days in the summer and from four to seven days in colder weather. The wire ties should be clipped immediately at that time and any rough edges rubbed and a cement-water paste placed in the holes.

Finishing

The first step in finishing concrete is screeding, which is striking off the excess concrete so the surface will have the proper contour and elevation. A piece of lumber may be used and it may have the lower edge straight or curved, depending upon what shape is desired. It should be moved back and forth across the concrete with a sawing motion and advanced forward a short distance with each movement. There should be a surplus of concrete against the front face of the screeding board so the depressions will be filled as they are passed over. Nothing more should be done until the concrete has begun to set.

The final finish can be put on after the set has begun but the concrete is still workable. The finish desired depends upon the use of the concrete. Usually, an even, yet gritty, non-slippery surface is wanted for sidewalks, driveways, and some floors. Basement floors are generally quite smooth, while some feeding floors and paved lots may be best very rough. A steel trowel is used for the very fine, smooth finish. A wood float is the best for an even, yet gritty and non-slippery surface, while a broom is used for a very rough surface. If an extremely rough surface is desired, water may be used with the broom to scrub away some of the cement-water paste and leave more aggregate exposed. Regardless of the finish, one should be sure to remove all surface water when finishing.

Curing

CURING is highly important for good concrete. As has been mentioned, the hardening of concrete is a chemical reaction between the cement and the water. This process continues for some time as long as moisture is present and the temperature favorable.

Research has shown that water tightness, durability, and strength increase with age if the concrete is cured under favorable conditions. Curing under water or keeping the surface moist for the first month after placing increases the strength materially. In addition, it prevents dusting and checking of the surface. The results of some tests under various curing conditions, ranging from tests at 7 days to 1 year in age, are given in figure 16. It is advisable to moist-cure for at least seven days. Burlap, canvas, sand, straw, and shavings are frequently used to hold moisture for curing. These should be sprinkled at frequent intervals so they remain continuously moist. It may be possible to use earth dikes and form a pond on flat surfaces.

In cold weather, the concrete must be protected from freezing. It is often covered with heavy paper, followed by 10 to 12 inches of straw. Sometimes, it may be possible to lay tarpaulins over the concrete or to hang them around it, as in the case of vertical walls.

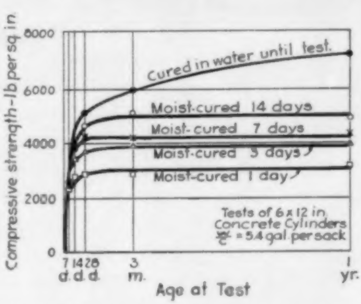


FIGURE 16. CONCRETE HARDENS BEST IN THE PRESENCE OF MOISTURE

This diagram shows relation between curing conditions and compressive strength of concrete.

Special Precautions and Processes

WHEN making concrete in freezing weather, one must take particular care to cover the mixture to prevent freezing. The aggregates and the mixing water should be heated, but never heated above 140° to 150° F. Occasionally, from 2 to 4 per cent of calcium chloride by weight of the cement is added to hasten setting.

Portland cement paint is often used on concrete structures. It can be purchased in several colors. The surface of the concrete should be dampened prior to applying the paint, and the paint should be scrubbed into the surface with a stiff brush. Best results are obtained if the surface is kept moist for 48 hours after it has been painted.

Farm Applications[1]

THE most common use for concrete on the farm is for foundation walls, floors, and footings. It is used also for sidewalks, drives, steps, ramps, water tanks, septic tanks, well covers, bull pens, hog wallows, dipping vats, farm bridges, and fence posts.

Floors

Concrete floors are easily constructed, have a long useful life, are easy to clean, and are convenient to work on. They are usually used both for interior floors and for outside feeding floors and exercise yards.

Before beginning to place a concrete floor, the area should be cleaned and leveled. It may also be sloped if a sloped floor is desired. When fill is used, it should be tamped thoroughly to insure a firm base for the floor. A well-drained base is essential to prevent settling. Adequate drainage should be provided if natural drainage is not satisfactory.

For most floors, a 6-gallon 1:2¼:3 concrete mix is suggested (table 1). Usually, 4-inch floors are thick enough unless heavy loads are anticipated, then a 6-inch floor should be used. The mix should be rather stiff so some vibrating and spading are necessary.

Interior floors may be in one section if they are not too large. There should always be an expansion joint between the walls and the floor.

Exterior floors should be placed in strips about 10 feet in width. Alternate strips are placed with forms to give a construction joint. After these strips have set, the intermediate strips are placed. Dummy joints, which are merely grooves, should be made at about 10-foot intervals across the strips. Should there be any cracking, it is usually in the dummy joints. It is a good practice to extend an apron or foundation wall below ground at the edges of floors to prevent undermining the floor. It may be advantageous to run this above the floor as well, to form a curb. Surface drainage can be taken care of by sloping the floor about ¼ inch a foot.

Foundations and footings

Often it is possible to use the earth as a form for foundations and footings if the soil is firm and will not cave. When forms are needed, wood is satisfactory. When the excavation is made for the footings and foundations, the soil removed should be placed far enough away so it will not interfere with the construction of the forms or fall into the trench.

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[1]More detailed information on foundations, footings, floors, paved barnyards, septic tanks, and other farm uses of concrete may be had by writing the Department of Agricultural Engineering, at Cornell University, Ithaca, New York.

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